AUTOMATION AND LITHIUM PRODUCTION

Jonas Berge, Emerson, Singapore, illustrates how automation can accelerate spodumene mining and refining processes.

The demand for lithium is growing, driven by the demand for batteries in electric vehicles (EV) and machines that use electric motors, instead of internal combustion engines, as a means of reducing emissions. The mineral known as spodumene is a critical source of lithium. Producing lithium at the required scale requires massive new infrastructure, made possible by a high degree of automation from the mining pit through the concentration plant, the refinery, and on to the battery factory. Automation of ore mining, processing, and refining thus plays a critical role in accelerating electrification and decarbonisation. Apart from a large amount of general-purpose process automation, many specialised automation solutions are also required that go beyond core process control. This article will highlight a few of these solutions that are particularly valuable for lithium production.

Optimising production processes

Ore is extracted and processed into spodumene concentrate near the mining site, then transported to the refinery where it is turned into lithium hydroxide or lithium carbonate used in

battery manufacturing. Advanced automation solutions beyond basic control loops are required for transfer chutes, hydrocyclones, grinding mills, and flotation cells.

Concentration plant production

One concertation plant production challenge for spodumene is moist material build up on the transfer chute walls, or oversized rocks getting lodged in the chute causing blockage, resulting in loss of production. Stopping to clear a blocked chute is labour intensive and involves costly downtime, and there is also an element of risk to the workers clearing the chute.

The solution is an online vibration monitor with non-intrusive sensors external to the chute, and expert system algorithms to monitor progressive buildup and predict blockage in real time, which estimates the degree of blockage as a percentage and provides escalating alarms as buildup progresses. Based on this information, operators can perform simple cleaning by water jet, or air jet, while production is still running before complete blockage occurs, or take other action like slowing down the conveyor belt. If there is a high degree of blockage they can plan for cleaning by shovel. The information enables operation to optimise the time of clearing. The result is a 15% reduction of downtime due to total chute blockage, and a 25% reduction of time to clear buildup, as well as reduced conveyor and chute damage due to undetected blockages.

Figure 1. Valve analytics drives valve performance and availability.

Figure 2. Wireless vibration monitor.

A second challenge is that insufficient grinding of the spodumene rock reduces yield in the flotation process, but excessive grinding speed causes high mill power consumption and energy cost. Grinding is a complex process with many interacting variables, which makes it difficult to maximise yield and throughput. Controls must balance feed rate, power consumption, grinding speed, and particle size. Even moisture content plays in. The solution is model predictive control (MPC), using multiple process variables to control mill speed to get the particle size 'just right' to maximise yield, maintaining throughput, while avoiding excessive power consumption. The result is reduced power consumption and cost, as well as enhanced lithium recovery.

A third challenge is that oversized spodumene rocks in the hydrocyclone can lead to roping and plugging. The hydrocyclone ceases to classify the material, resulting in recovery losses. It also causes pipe blockages or sanding of underflow tanks and unplanned downtime to clear. There is even a risk of downstream equipment damage. The solution is an online vibration monitor and expert system algorithms to predict and detect roping and plugging, as well as estimate particle size in real time. The result is improved lithium recovery, reduced downtime from clearing blocks and sanding, lower maintenance costs from downstream damage, and improved product quality.

A fourth concentration challenge is that spodumene flotation cell reagent is expensive, so dosing too much is costly, but too little and the recovery yield is low. Flotation is also a complex process with many interacting variables, such as: chemical dosing flow, air flow, aeration sparging, agitation speed, particle size, and level. Ore concentration also plays a part. And there are multiple cascading flotation cells, each cell affected by the one before it. The solution here too is MPC using multiple process variables to control reagent flow to maximise product recovery yield, while minimising reagent consumption. The result is 2% improvement in recovery and reduced chemicals costs.

Refinery production

One refinery challenge is that chemicals and fuel gas are costly, so inaccurate and unresponsive control valve movement causes unnecessary costs to be incurred, as well as process variability and the delivery of off-spec product. The solution is smart valve positioners (Figure 1) and valve analytics software with control valve performance diagnostics – to detect inaccurate and unresponsive control valve movement and recommend corrective action to restore valve performance. Plant personnel can take action to reinstate responsive and accurate control. The result is reduced off-spec product and reduced fuel and chemicals consumption.

Improving reliability with automation

Automation solutions are required to support maintenance of the equipment along all stages of the process.

Many operational challenges stem from traditional ways of working, such as manual data collection and manual data interpretation. To improve performance and profitability, many automation solutions go beyond core process control.

Reliability in the mining pit and concentrator plant

One reliability challenge in the spodumene mining pit is electric rope shovel failure. The propel, hoist, and crowd systems are prone to wear-and-tear and may fail unexpectedly. Manual data collection is infrequent and labour intensive and does not detect problems that may occur between periods of data collection, resulting in unplanned production downtime and high maintenance cost. Manual data collection also means personnel exposure in remote high-risk areas. The solution is an online vibration monitor and vibration analytics software to predict failure of transmission, motor imbalance, and bearing failure in propel, hoist and crowd systems, so personnel can plan overhauls before they fail. The result is reduced production loss, as well as reduced logistics and maintenance costs.

A reliability challenge in spodumene concentration plants is wear-and-tear of crushers, mills, stackers and conveyor belts, which may fail unexpectedly causing unscheduled production shutdowns and high maintenance costs. The solution is permanent wireless vibration sensors (Figure 2) and vibration analytics software, which are able to predict equipment failure so personnel can plan overhauls before failures occur. The result is fewer unplanned plant shutdowns and production losses, reduced maintenance costs, and extended equipment life.

Yet another reliability challenge is the hydrocyclone isolation valves in spodumene slurry service, which are prone to jam and experience seat failures. This causes unscheduled production shutdown and high maintenance cost. Isolation valves (Figure 3) with full port and tight shut-off capabilities can solve these problems. The most unique feature of this type of valve is the replaceable urethane liner. The two body halves are unbolted and the liner simply pops out and a new one clicks into place, which is very easy to maintain. This helps reduce unplanned shutdowns and production losses, lower maintenance costs, and extended valve life.

Refinery reliability

One refinery reliability challenge is that control valves in spodumene slurry service erode, causing unstable flow control and process leakage that affects the process operation and shorts the service life of the control valves. The solution is ceramic trim on eccentric plug valves, which provides good wear resistance for slurry applications. The unique feature of the eccentric plug is that when it opens it moves away from the seat, so there is no rubbing; like there would be in the case of an ordinary ball or v-ball valve. The result is reduced maintenance costs, extended service life, reduced process variability, reduced unplanned shutdown, and greater safety.

Another reliability challenge is wear-and-tear on pumps and other equipment causing failure and unscheduled production shutdowns with associated high maintenance costs. The solution is condition monitoring analytics software with underlying wireless vibration sensors and other sensors that use rule-based artificial intelligence with cause and effect and first principles for robust predictions. The result is extended equipment life, reduced maintenance costs, improved maintenance planning, and fewer unplanned plant shutdowns.

Figure 3. Isolation valve with replaceable parts.

Automation for sustainability

A sustainability challenge in the lithium refinery is the combustion in spodumene kilns. Too much air reduces efficiency. Too little air cause incomplete combustion increasing emissions. Fuel flow, fan speed, and product flow are manipulated; excess oxygen, hot-end, cold-end, and hood temperature are controlled; and multiple fuels with different heating value may be used, so process control is not simple. The solution is MPC using multiple process variables to ensure optimum fuel economy and complete combustion. The result is greater energy efficiency and reduced SOx and NOx emissions.

Mining 4.0

By automating the lithium production value chain with the right solutions that are specialised for the harsh conditions of mining and processing, these automation technologies can maximise lithium recovery, minimise energy consumption, and associated cost. In the spirit of Industry 4.0, these solutions go beyond just improving production; they provide data and analytics for predictive maintenance to reduce downtime and maintenance cost as well. GMR